CHAPTER 10. VHF/UHF/SHF NAVIGATIONAL AID (NAVAID) FREQUENCY ENGINEERING

1000. PURPOSE. The purpose of this chapter is to present an overview of the frequency engineering necessary for ILS, VOR, VHF Omnidirectional Radio Range Test (VOT), Area VOT (AVOT), Distance Measuring Equipment, Normal (DME/N), Precision Distance Measuring Equipment, Precision (DME/P), Tactical Air Navigation (TACAN), Microwave Landing System (MLS) and Differential Global Positioning System (DGPS) Special Category I (SCAT-I). The detailed frequency engineering for these NAVAID facilities is discussed in the appendix.

1001. NAVAID FREQUENCY ALLOCATION. NAVAID facilities are dependent upon the use of the RF spectrum. A summary of the present international and national frequency allocations for NAVAID is shown in figure 10-1. All frequencies for VHF/UHF/SHF NAVAID's, except for ILS Marker Beacon, are channelized and paired within the listed bands as shown in the appendix.

FIGURE 10-1. NAVAID BAND USE

FACILITY TYPE	FREQUENCY BAND (MHZ)
ILS LOCALIZER (LOC)	108.1 - 111.95
DGPS SCAT-I	112.0 - 117.975
ILS GLIDESLOPE (GS)	328.6 - 335.40
ILS MARKER BEACON	75
VOR, VOT, AVOT	108.00 - 117.975
DME/N, DME/P, TACAN	960.0 - 1215.0
MLS	5031.0 - 5091.0

1002. BASIC PRINCIPLES OF NAVAID FREQUENCY ENGINEERING. Due to the fixed number of frequencies available for NAVAID facilities, each NAVAID frequency is reused as often as possible throughout the country. NAVAID frequency engineering provides an interference-free assigned environment for each NAVAID facility within its FPSV. Each type of NAVAID has its own characteristic FPSV, and each is defined in the appendix. Basically, NAVAID frequency engineering involves two frequency analyses: intersite and cosite.

a. Intersite Analysis is necessary to prevent RFI between facilities on the same and adjacent frequencies providing service in different areas. The basic factor considered in intersite analysis is the D/U ratio, as seen at the airborne NAVAID receiver input. All NAVAID frequency assignments must meet certain D/U ratio values (see the appendix). For example, a VOR assignment must meet 23 dB for cochannel D/U within its FPSV. The 23 dB is based upon the avionics and ICAO standard of required 20 dB D/U, with the addition of a 3 dB factor to allow for the facility power decreasing 3 dB before its monitor shuts it down. The required D/U ratios for each type of VHF/UHF/SHF NAVAID for cochannel and adjacent channels are provided in the appendix.

b. Cosite Analysis is necessary to prevent RFI resulting from the interaction of transmitters and receivers at or near the same site. Cosite RFI includes intermod, cross-modulation, receiver desensitization (overload), adjacent channel signals, harmonics and AM/FM/TV interference.

1003. NAVAID FREQUENCY ENGINEERING METHODS. The cosite analysis procedure is discussed in the appendix. It will not be repeated in this chapter. As for intersite analysis, there are two basic methods for determining whether a proposed frequency meets the required D/U ratio criteria.

a. Method 1: Use of Reference Tables. A series of reference tables will be found in the appendix, which show conservative worst-case separation distances required for each NAVAID type. If the proposed new facility meets all the separation requirements of appropriate reference tables, no further search is necessary, and the frequency application may be prepared. This method is discussed in detail in the appendix.

b. Method 2: Calculation of Required Separation. In frequency congested areas, it is necessary to use a more accurate and detailed method of determining the required separation distance. The calculation method takes the following equipment parameters into consideration and the required D/U ratio is adjusted accordingly:

(1) Transmitter power.

(2) Antenna gain.

(3) Antenna directivity.

(4) Antenna orientation.

1004. EQUIVALENT SIGNAL RATIO (ESR). The adjusted D/U ratio is called ESR. A series of curves based on this ESR will be found in the appendix, showing the required separation distance. The detailed procedure for calculating the ESR and using the curves is discussed in the appendix.

1005. EXPANDED SERVICE VOLUME (ESV). An ESV is a special volume of airspace outside of the normally specified FPSV. Each ESV is engineered using the same criteria as for FPSV. In addition to meeting the required D/U ratio criteria, each ESV shall also meet certain minimum signal strength requirements as prescribed in the appendix. Since ESV's are not registered in the NTIA GMF, ASR maintains a separate data base within the AFM for all ESV's used in the NAS. The detailed procedures for engineering ESV's and updating the ESV data base are discussed in the appendix.

1006. SPECIAL ISSUES TO BE CONSIDERED.

a. NAVAID 50 kHz Assignments. Since many general aviation aircraft are not yet equipped with 50 kHz (200-channel) navigation receivers, every effort shall be made to find a 100 kHz assignment for a NAVAID facility.

b. Paired NAVAID Assignments. To minimize a potential safety hazard, frequency protection shall be provided for all services associated with a facility, even if only one service is installed. When an ILS LOC is assigned, the associated DME frequency shall be frequency protected even if no DME is installed. The same holds true for VOR/DME/TACAN and MLS/DME/P and MLS/DME/N.

c. Localizer Receiver Desensitization Due to In-Band Localizer Signals. Interference between localizers serving different runways at the same airport is possible depending on the configuration of the runways and the distance between the two systems. When an aircraft on approach passes through a strong radiation field of a localizer serving a reverse or an adjacent runway, the ILS siting criteria (FAA Order 6750.16) requires that a positive interlock device be installed to prevent both systems from transmitting simultaneously. FMO's may be asked to evaluate waivers to this siting policy at airports where more efficient use of runways is required. The FMO must analyze the specific situation and geometry so that airborne ILS avionics are not desensitized due to other localizers at the airport. The following policy is provided:

(1) An undesired localizer signal level of -33 dBm will not be exceeded within the FPSV of a colocated ILS.

(2) Calculations will be done using the free space formula.

d. VOR/DME/TACAN Colocation Assignments. Some VOR/DME/TACAN facilities which were in place in 1980 were engineered under criteria slightly different than that shown in the appendix. As such, any installations which have passed flight inspection satisfactorily in the past shall be considered as conforming to these criteria. However, any new facility frequency engineered shall adhere to the criteria presented in the appendix.

(1) The greater distance separation of the individual frequency paired VOR/DME/TACAN shall be used. In facilities of equal power, the criteria charts and graphs will show that the DME/TACAN required separation is greater than that of any paired VOR for most conditions.

(2) In all cases, the GREATER requirement shall be used as minimum separation for the frequency pair, regardless of whether both paired facilities are installed.

e. DME at ILS Locations. ILS/DME's generally require separation distances far beyond that provided for the LOC's due to the DME's separation criteria and omnidirectional antenna pattern. Therefore, it is important to ensure that when engineering an ILS LOC frequency, its associated DME meets the required separation, even if no DME is installed. In frequency congested areas, the frequency protection for the DME may not be possible without using 50 kHz NAVAID frequencies. If the DME is not actually installed, the DME frequency protection may be waived through the normal NAS Change Proposal (NCP) process.

f. DME/P and DME/N at MLS Locations. The conditions are the same as with DME at ILS locations.

g. Potential FM/TV Interference. Because of an abundance of FM and TV high power transmitters around the country, an approach or an airway may place an aircraft over or very near one of these transmitters. Their overwhelming power, frequently on the order of a megawatt or more ERP, can cause severe overloading of the front end of aircraft receivers, and thus the loss or deterioration of NAVAID reception. A routine item to be checked for problems in a frequency study shall include the verification of nearby FM or TV transmitters. Of particular concern are the FM transmitters near the upper end of the FM broadcast band because it is immediately adjacent to the 108.0-117.975 MHz NAVAID band. All new ILS and VOR proposals will be evaluated using the AAM to ensure there is no interference from FM and TV Broadcast stations. See the appendix for further discussion of FM/TV interference.

h. Colocated NAVAIDS. At some sites, a VOR/DME/TACAN or ILS/DME paired facilities may not be actually colocated. To meet ICAO and FAA standards, such paired facilities must be installed within the distances specified in the appendix, or else the two facilities may not be frequency paired. An ILS/DME may be colocated with either the LOC or the GS transmitters.

i. Terrain Shielding. A transmitter's signal strength in space can be affected by the shielding of terrain, buildings, vegetation, etc. This can have an impact on the D/U signal ratios in space. If shielding is severe, it may be possible to provide the required D/U signal ratios with less than the recommended station separation. The use of terrain shielding, as a way to decrease separation requirement, should be treated on a case-by-case basis through sound engineering judgment. This facility must be flight checked with satisfactory results and documented through the normal NCP process.

j. All requests for all local area augmentation system spectrum support, for example, DGPS SCAT-I frequency assignments, will be referred to ASR for engineering and assignment action.

1007. thru 1099. RESERVED.